NATIONAL BUREAU OF STANDARDS REPORT

6205

AN INTERIM REPORT ON BOILING TESTS
OF
INSULATIONS FOR UNDERGROUND HEAT DISTRIBUTION SYSTEMS

by

Selden D. Cole and Paul R. Achenbach

to
Office of the Chief of Engineers
Bureau of Yards and Docks
Department of the Air Force

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

Reports and Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Inquiries regarding the Bureau's reports should be addressed to the Office of Technical Information, National Bureau of Standards, Washington 25, D. C.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT
1003-20-4881

NBS REPORT
6205

October 28, 1958

AN INTERIM REPORT ON BOILING TESTS
OF
INSULATION FOR UNDERGROUND HEAT DISTRIBUTION SYSTEMS

by

Selden D. Cole and Paul R. Achenbach
Air Conditioning, Heating, and Refrigeration Section
Building Technology Division

to

Office of the Chief of Engineers
Bureau of Yards and Docks
Department of the Air Force

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

AN INTERIM REPORT ON BOILING TESTS OF INSULATION FOR UNDERGROUND HEAT DISTRIBUTION SYSTEMS

by

Selden D. Cole
and
Paul R. Achenbach

1. Introduction

As part of a research program on the characteristics required of insulations to be used in underground heat distribution systems, boiling tests were made of selected insulating materials that have been used in this application. The boiling test procedures followed those incorporated in the new specification of the Office of the Chief of Engineers dated March 24, 1958, based on the recommendations contained in Federal Construction Council Technical Report No. 30, prepared by the Building Research Advisory Board.

The test procedure requires that an 8-foot specimen of the insulation be applied to a nominal 4-inch pipe in a tank, submerged with water, and boiled for 72 hours by maintaining 125 psig steam pressure on the 4-inch pipe. After drying for 24 hours, the specimen is to be evaluated in terms of eccentricity, cracking, rupturing, swelling, fraying, material fallen from the pipe, and separation of the joints.

2. Specimens Tested

Five materials have been subjected to this boiling test: Kaylo, Thermobestos, Unibestos, Foam-Sil, and Fiberglas. Some have been tested more than once and Fiberglas has been tested in blanket, loose fill, and premolded forms. Loose fill Fiberglas has also been boiled for 72 hours inside a clay tile conduit system. Some experimentation has been conducted on methods for covering the insulating material and for securing it on the pipe. The specimens that have been tested are summarized in the following table.

AN INTERIM REPORT ON BOILING TESTS OF INSULATION FOR UNDERGROUND HEAT DISTRIBUTION SYSTEMS

by

Selden B. Cole
and
Paul R. Achenbach

1. Introduction

As part of a research program on the characteristics required of insulations to be used in underground heat distribution systems, boiling tests were made of selected insulating materials that have been used in this application. The boiling test procedures followed those incorporated in the new specification of the Office of the Chief of Engineers dated March 24, 1950, based on the recommendations contained in Federal Construction Council Technical Report No. 20, prepared by the Building Research Advisory Board.

The test procedure requires that an 8-foot specimen of the insulation be applied to a nominal 4-inch pipe in a tank, submerged with water, and boiled for 72 hours by maintaining 125 psig steam pressure on the 4-inch pipe. After drying for 24 hours, the specimen is to be evaluated in terms of eccentricity, cracking, rupturing, swelling, fraying, material falling from the pipe, and separation of the joints.

2. Specimens Tested

Five materials have been subjected to this boiling test: Kaylo, Thermobestos, Unibestos, Noma-Sil, and Fiberglas. Some have been tested more than once and Fiberglas has been tested in blanket, loose fill, and premolded forms. Loose fill Fiberglas has also been boiled for 72 hours inside a clay tile conduit system. Some experimentation has been conducted on methods for covering the insulating material and for securing it on the pipe. The specimens that have been tested are summarized in the following table.

SPECIMEN IDENTIFICATION

SPECIMEN	NAME	THICKNESS	HOURS OF BOILING
1	Molded fiberglas, Standard	1 in.	72
2	Kaylo	1 in.	72
3	Foam-Sil	3 in.	72
4	Unibestos	1.5 in.	72
5	Fiberglas-Ric-Wil	1.5 in.	72 + 72
6	Fiberglas-1/4 mesh, loose fill	1.5 in.	72
7	Thermobestos	1.5 in.	72
8	Molded fiberglas, Low Temperature	1.5 in.	48 + 72
9	Molded fiberglas, Low Temperature	1.5 in.	72
10	Foam-Sil	1.5 in.	72 + 72
11	Thermobestos	1.5 in.	72 + 72
12	Fiberglas-1/4 mesh, loose fill	1.5 in.	72
13	Fiberglas-16 mesh, loose fill	1.5 in.	72
14	Kaylo	1.5 in.	72 + 72
15	Molded fiberglas, Standard	1.5 in.	72 + 72
16	Fiberglas-Stillwater, Conduit - loose fill	1.7 in. min.	72

SPECIMEN IDENTIFICATION

SPECIMEN	NAME	THICKNESS	HOURS OF BOILING
1	Molded Fiberglas, Standard	1 in.	72
2	Kayle	1 in.	72
3	Foam-Sil	3 in.	72
4	Unibestos	1.5 in.	72
5	Fiberglas-Mle-Wil	1.5 in.	72 + 72
6	Fiberglas-1/4 mesh, loose fill	1.5 in.	72
7	Thermobestos	1.5 in.	72
8	Molded Fiberglas, Low Temperature	1.5 in.	48 + 72
9	Molded Fiberglas, Low Temperature	1.5 in.	72
10	Foam-Sil	1.5 in.	72 + 72
11	Thermobestos	1.5 in.	72 + 72
12	Fiberglas-1/4 mesh, loose fill	1.5 in.	72
13	Fiberglas-30 mesh, loose fill	1.5 in.	72
14	Kayle	1.5 in.	72 + 72
15	Molded Fiberglas. Standard	1.5 in.	72 + 72
16	Fiberglas-Sclikmeter, Conduit - loose fill	1.7 in. min.	72

3. Discussion and Conclusions

The conclusions drawn regarding the effect of boiling on five types of insulation, as indicated by the results of the tests, are summarized below, followed by some general conclusions regarding the application of insulations to underground piping. These conclusions are based on the test results summarized in Section 4 of this report. The results in successive tests of the same material were not always consistent. Thus, a more comprehensive study might lead to some modifications in the conclusions.

Effect of Boiling on Five Types of Insulation

Kaylo: This insulation will probably withstand 72 hours or more of boiling without falling off the pipe or being cut into pieces if straps are used to secure it to the pipe. Appreciable erosion occurs at the joints in 3 to 6 days of boiling, such that a gap of an inch or more may develop at the joints.

Thermobestos: This insulation appears to swell some during boiling, placing straps under tension. Light gage aluminum straps were sheared at the eye on this material. Longitudinal joints tend to open a little during boiling, perhaps due to swelling, and a slight erosion occurred at the joints. In one test, none of the insulation fell off the pipe in 72 hours, when supported by straps or wires. In a second test, three sections in succession broke and each fell off within 72 hours, using straps for support in each case.

Unibestos: Based on the results of one test only, it appears that this material will remain on the pipe for 72 hours, under boiling conditions, with appreciable spalling or sloughing off of the outer layers. The binder is leached out, leaving the outer surface soft and spongy as contrasted to its hard character when new. There appears to be no swelling of the material. It adheres to the pipe after boiling.

3. Discussion and Conclusions

The conclusions drawn regarding the effect of boiling on five types of insulation, as indicated by the results of the tests, are summarized below, followed by some general considerations regarding the application of insulations to underground piping. These conclusions are based on the test results summarized in Section 4 of this report. The results in successive tests of the same material were not always consistent. Thus, a more comprehensive study might lead to some modifications in the conclusions.

Effect of Boiling on Five Types of Insulation

Kaylo: This insulation will probably withstand 72 hours or more of boiling without falling off the pipe or being cut into pieces if straps are used to secure it to the pipe. Appreciable erosion occurs at the joints in 3 to 6 days of boiling, such that a gap of an inch or more may develop at the joints.

Thermobestos: This insulation appears to swell some during boiling, placing straps under tension. Light gage aluminum straps were observed at the eye on this material. Longitudinal joints tend to open a little during boiling, perhaps due to swelling, and a slight erosion occurred at the joints. In one test, none of the insulation fell off the pipe in 72 hours, when supported by straps or wires. In a second test three sections in succession broke and each fell off within 72 hours, using straps for support in each case.

Unibestos: Based on the results of one test only, it appears that this material will remain on the pipe for 72 hours, under boiling conditions, with appreciable spalling or slumping off of the outer layers. The binder is leached out, leaving the outer surface soft and spongy as contrasted to its hard character when new. There appears to be no swelling of the material. It adheres to the pipe after boiling.

Foam-Sil: The Foam-Sil material itself does not appear to be affected by boiling water. There is virtually no erosion or other loss of material. The cement used to seal the layers together in manufacture is weakened in 144 hours of boiling and some sections could be pulled apart by hand, although none came apart during the 144-hour boiling test. It is a brittle, friable material and can be cut by the supporting straps if a section becomes slightly loose on the pipe and starts to vibrate as a result of the boiling action. Binding the material too tightly to the pipe may cause it to crack when the pipe expands. This is a closed-cell insulation which limits the access of water to the steam pipe somewhat under flooded conditions.

Fiberglas: This material has been subjected to boiling water under the following conditions and in the following forms:

a. Loose fill supported on a pipe with 1/4-inch hardware cloth.
b. Loose fill supported on a pipe with 16-mesh wire screen.
c. Loose fill in the Stillwater Clay Products conduit.
d. Molded 1" thick supported by straps and wires.
e. Molded 1-1/2" thick supported by straps and wires.
f. Molded 1-1/2" thick supported by 16-mesh screen.
g. Blanket wrap 1-1/2" thick, Nic-Wil, supported by plastic mesh.

In all forms of Fiberglas, the boiling water causes a leaching action in the glass fibers which weakens them and causes them to break into short pieces. This action progressed more rapidly near the pipe than at greater distances. At the end of 72 hours of boiling, an appreciable amount of the material near the pipe appears to the naked eye to be pulverized to a consistency of dust, but a microscopic examination shows that it still has a fibrous character although there is a tangled appearance to the fibers. Somewhat farther out from the pipe, the individual fibers are covered with translucent blisters or even clusters of such blisters. The nature of these blisters is not known unless it is the products of the leaching action of water on the glass.

The effectiveness of the material as an insulation does not appear to be greatly reduced by boiling as long as the insulation remains on the pipe in its original thickness and without voids.

Prolonged boiling of the insulation in a tank appears to progressively break up the fibers and eventually substantial amounts of the material are lost by falling into the bottom of the tank. The rate at which this loss occurs, appears to be related to the uniformity of packing the fibers, the density of the pack, whether or not a binder us used, and the size of openings in the covering material. Generally speaking, a factory-made insulation envelope consisting of compressed blankets of Fiberglas will not deteriorate as rapidly as loose fill material applied to the pipe by hand. Insulation, wrapped in a 16-mesh plastic or metal screen, will not be lost as rapidly as the same material wrapped in 1/4-inch hardware cloth.

Factory-made envelopes using blanket Fiberglas insulation, as made by the Ric-Wil Company, premolded Fiberglas 1-1/2 inches thick and wrapped with 16-mesh screen, and premolded Fiberglas 1-1/2 inches thick, secured with steel bands at 1-foot intervals, will all withstand 72 hours of boiling without appreciable loss of material. Loose fill Fiberglas hand packed to a density of 7-1/2 pounds will suffer appreciable loss in 72 hours boiling with either 16-mesh or 1/4-inch mesh wrapper. The factory-made blanket envelope and the premolded envelope wrapped in wire mesh both suffer noticeable loss of material after boiling 144 hours whereas, a section of the premolded material, supported by straps, fell off the pipe during 144 hours of boiling.

Boiling loose fill Fiberglas insulation inside a clay tile conduit system of the type manufactured by the Stillwater Clay Products Company resulted in the loss of an appreciable amount of material within 3 feet of the vent pipe at one end, and very little loss in the remainder of the test specimen during a 72-hour boiling period. The vent pipes were attached to the conduit at the top of the arch tile. The insulation was packed to a density of 5.5 lb/cu ft.

In a typical installation, such a system would probably be vented from the side blocks instead of at the top of the arch. In this case, the steam would leave the insulation cavity through the upper holes of each of the ventilated side blocks and the water level would be at about this same height. The presence of a steam space in the upper part of the arch tile would probably reduce the mechanical agitation within the insulation as compared to that when the conduit was completely filled with water. By using 16-mesh screen over the openings in the side block, the loss of material at these openings could be reduced. It is probable that a solid enclosure for loose fill insulation, such as that used in the clay tile system, would prevent loss of fibrous material during a boiling period of 72 hours as effectively as a screen mesh wrapper in the boiling tank, if not more so.

On the other hand, it is also probable that prolonged boiling of Fiberglas insulation over a period of many days in a clay tile system would seriously deteriorate the insulation, so such a system should not be used where frequent flooding could occur.

General Conclusions

Wire bands should not be used to secure insulation on pipes underground.

Straps should not be made of light-gage metal. Expansion of the insulation can cause the eyes to cut light-gage straps.

Molded insulation should fit the pipes snugly. Loose sections of insulation will often vibrate on the pipe during boiling and cause the straps to cut the insulation into pieces.

Brittle materials should not be strapped so tightly that pipe expansion will put tension on the insulation.

Except for the cellular glass, the boiling water will cause some erosion at the longitudinal joints and the butt joints between adjacent lengths. It will also erode channels or holes through the body of fibrous insulations.

Complete wrappers of wire mesh or suitable plastic mesh (16-mesh or smaller) will probably minimize spalling and sloughing off of insulation on an underground pipe more effectively than straps under boiling conditions.

The boiling tests made thus far indicate that all five of the materials tested will probably deteriorate significantly if boiling continues indefinitely. Foam-Sil was probably the least affected by boiling, but the fit of the material on the pipe may determine the likelihood of cracking the insulation or its tendency to vibrate on the pipe.

The deleterious effect of boiling water on most insulating material now used for underground piping systems, as revealed by these tests, emphasizes the need for continuous effort to design such systems so they will function many years before water gains access to the insulation, no matter what the nature of the terrain.

4. Test Results

The results observed during each boiling test are summarized separately in this section. The summary identifies the material and its dimensions, the method of application, the condition of the insulation at the conclusion of the boiling test, and one or more photographs of each specimen.

BOILING TEST OF PIPE INSULATION

Specimen 1

Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Pre-molded Fiberglas PF, Standard

Binder used: Organic thermosetting resin

Length of section: 3 ft

Thickness of insulation: 1 in.

Covering: Light cloth fabric

Pipe diameter: 4 in.

Method of Application

Method of fastening: 1st section - Four 3/4-in. straps, 1 ft apart
2nd section - Four No. 12 copper wires, 1 ft apart

Position of joints: 1st section - Joints vertical
2nd section - Joints horizontal

Covering used: Light cloth fabric

Other features: Fourth strap on 1st section covered lapped fabric at joint between sections

Test Results

Amount fallen from pipe: Top half of 1st section fell off. Bottom half dropped down and resting on straps. 2nd section intact.

Eccentricity: None on 2nd section

Separation at joints: None on 2nd section

Cracks and ruptures: None on 2nd section

Fraying: None

Swelling: Slight swelling on 2nd section

Erosion: Some erosion on interior surface and at joints

Other damage: None

Moisture retention: Not measured
Percent

Reference to photographs: Fig 1 shows initial appearance; right specimen.
Fig 3 shows 1st section gone after 72 hours; right specimen.
Swelled appearance of 2nd section is primarily the stretched fabric covering.

Figure 1

Figure 3

BOILING TEST OF PIPE INSULATION

Specimen 2

Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Kaylo - Pre-molded calcium silicate and asbestos fibers

Binder used: Calcium silicate

Length of section: 3 ft

Thickness of insulation: 1 in.

Covering: Light cloth fabric

Pipe diameter: 4 in.

Method of Application

Method of fastening: 1st section - Four 3/4-in. straps, 1 ft apart
2nd section - Four No. 12 copper wires, 1 ft apart

Position of joints: 1st section - joints vertical
2nd section - joints horizontal

Covering used: Light cloth fabric

Other features: Fourth strap on 1st section covered lapped fabric at joint between sections

Test Results

Amount fallen from pipe: Parts of 2nd section. See Fig. 3; left specimen. 1st section intact.

Eccentricity: None.

Separation at joints: None

Cracks and ruptures: Insulation cut by wires on 2nd section and broken into pieces. Top half of 2nd section dislocated. See Fig 3; left specimen.

Fraying: None

Swelling: None

Erosion: Some erosion at joints

Other damage: Cloth fabric torn on 2nd section

Moisture retention: Not measured
Percent

Reference to photographs: Fig 1 shows initial appearance; left specimen.
Fig 3 shows rupture of 2nd section as it appeared after 72 hr of boiling; left specimen.

BOILING TEST OF PIPE INSULATION

Specimen 3

Description of Material

Manufacturer: Pittsburgh Corning Company

Identification name or symbol: Foam-Sil. Pre-sealed closed cell glass foam.

Binder used: None. Fused material. Each piece made of two layers cemented together longitudinally.

Length of section: 17 in.

Thickness of insulation: 3 in.

Covering: None

Pipe diameter: 4 in.

Method of Application

Method of fastening: 1st and 2nd sections - Two 3/4-in. straps, 2 in. from ends.
3rd section - One strap and one wire, 2 in. from ends.
4th and 5th sections - Two No. 12 copper wires, 2 in. from ends.

Position of joints: 1st, 3rd, 5th sections - joints vertical
2nd, 4th sections - joints horizontal

Covering used: None

Other features: None

Test Results

Amount fallen from pipe: None

Eccentricity: 4th section cut by wire break. Lower half dropped slightly from slack in wires.

Separation at joints: None

Cracks and ruptures: Vibration of fourth section caused wires to cut into insulation, but it was not severed. See Fig 4, left specimen.

Fraying: None

Swelling: None

Erosion: Negligible

Other damage: None

Moisture retention: Not measured. Non-hygroscopic material.
Percent

Reference to photographs: Fig 2 shows initial appearance, left specimen.
Fig 4 shows appearance after 72 hr boiling. Dislocation of 4th section from cutting by wires shown in left specimen.

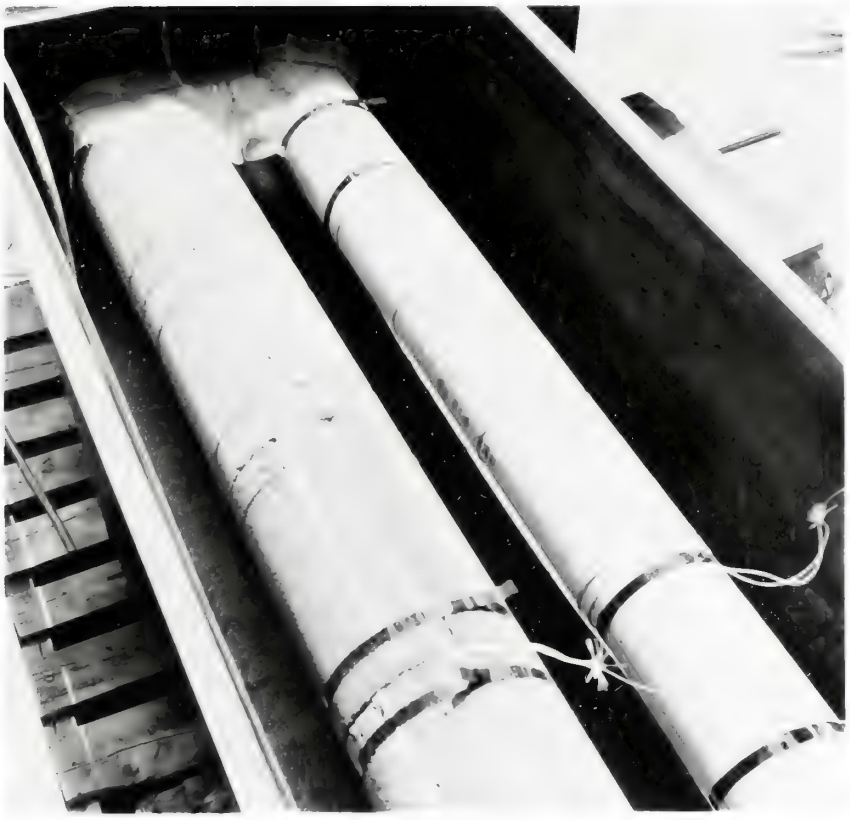

Figure 2

Figure 4

BOILING TEST OF PIPE INSULATION

Specimen 4

Description of Material

Manufacturer: Union Asbestos and Rubber Company

Identification name or symbol: Unibestos. Pre-molded magnesia fibers.

Binder used: Silicate

Length of section: 3 ft

Thickness of insulation: 1 1/2 in.

Covering: None. Exterior surface made quite hard with binder material.

Pipe diameter: 4 in.

Method of Application

Method of fastening: 1st section - Four 3/4-in. straps, 1 ft apart
2nd section - Four No. 12 copper wires, 1 ft apart

Position of joints: 1st section - joints horizontal
2nd section - joints vertical

Other features: None

Test Results

Amount fallen from pipe: None

Eccentricity: None

Separation at joints: None

Cracks and ruptures: None

Fraying: Slight

Swelling: Negligible

Erosion: About 1/4 of material was lost from outer surface of top half of 1st section. See Fig 4, right specimen.

Other damage: Water leached out of insulation. Surface appreciably softened.

Moisture retention: 9.7 percent

Reference to photographs: Fig 2 shows initial appearance; right specimen.
Fig 4 shows loss of material on top of 1st section; right specimen in foreground.

Comments: Both sections adhered to the pipe at the end of the test. A scraper had to be used to loosen the insulation

BOILING TEST OF PIPE INSULATION

Specimen 5

Description of Material

Manufacturer: Ric-Wil - Sectional Fiberglas Pipe Insulation

Identification name or symbol: - Blanket Fiberglas as used by Ric-Wil.

Binder used: Fiberglas oiled treatment only

Length of section: 2 ft with overlapping screen joints

Thickness of insulation: 1-1/2 inches - 7-1/2 lbs density

Covering: 14 x 16 mesh fiberglas strands plastic coated.

Pipe diameter: 4 in.

Method of Application

Method of fastening: Prepared sections slipped on pipe

Position of joints: Only butt joints in this construction

Covering used: Fiberglas screen held with metal staples.

Other features: 2 in. lap of covering at butt joints.

Test Results

Amount fallen from pipe: Slight loss after 72 hr.

Eccentricity: Slight

Separation at joints: None after 72 hrs - open after 144

Cracks and ruptures: None after 72 hrs.

Fraying: None

Swelling: None after 72 hrs.

Erosion: Slight after 72 hrs.

Other damage: Plastic covering brittle after 144 hrs.

Moisture retention (percent): Dry

Reference to photographs: Fig 5 - after 72 hrs boiling
Fig 6 - buttjoint uncovered to show negligible loss of wool
Fig 7 - after 144 hrs boiling shows some loss of Fiberglas wool

Figure 5

Figure 6

Figure 7

BOILING TEST OF PIPE INSULATION

Specimen 6

Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Loose-fill Fiberglas

Binder used: None

Length of section: 7'-2"

Thickness of insulation: 1.5 in.

Covering: 1/4 in. mesh galvanized hardware cloth used to retain loose fill insulation on pipe

Pipe diameter: 4 in.

Method of Application

Method of fastening: A weighed amount of loose fill Fiberglas was spread as evenly as possible on a flat piece of 1/4 in. mesh hardware cloth and held in place with big stitches of cotton string. See Fig 8 and 9. Even though the insulation was spread as evenly as possible, there was an appearance of clumps in the layer and probable variations in density. The width of the mesh wrapper and the amount of insulation used was such that the insulation would be compressed to a density of 7lb/cu ft and a thickness of 1-1/2 in. when wrapped around the pipe with the wire mesh overlapping one inch at the edges. The wire mesh wrapper was held in place with 3/4 in. bands spaced 12 in. apart.

Test Results

Amount fallen from pipe: About 30 percent as weighed dry before and after boiling

Other damage: 4 in. pipe exposed in many places as voids appeared in an irregular pattern in the insulation

Reference to photographs: Fig 8, left specimen, shows appearance after 72 hrs boiling
Fig 9 shows close-up view of voids in the insulation

Figure 8

Figure 9

BOILING TEST OF PIPE INSULATION

Specimen 7

Description of Material

Manufacturer: Johns-Manville

Identification name or symbol: Thermobestos

Binder used: A calcium silicate product with asbestos fibers

Length of section: 36 in.

Thickness of insulation: 1-1/2 in.

Covering: None

Pipe diameter: 4 in.

Method of Application

Method of fastening: 1st section - 4 straps
2nd section - #12 copper wire
3rd section - strapped

Position of joints: 1st section - Joints horizontal
2nd section - Joints vertical
3rd section - Joints horizontal

Covering used: None

Other features: 3rd section - was about 15 in. long.

Test Results

Amount fallen from pipe: None

Eccentricity: None

Separation at joints: Slight, except short piece which opened up so that pipe was exposed.

Cracks and ruptures: None

Fraying: None

Swelling: None

Erosion: Slight outside edge of all joints

Other damage: Wire cut into insulation a distance equal to its diameter in some places

Reference to photographs: Fig 8, right specimen, shows appearance after 72 hrs boiling. Note slight separation of longitudinal joint and slight embedment of wire at farther end of the middle section

BOILING TEST OF PIPE INSULATION

Specimen 8

Description of Material

Manufacturer: Owens-Corning Fiberglas

Identification name or symbol: Preformed 1.5 in. Fiberglas (low temperature)

Binder used: Organic thermosetting resin

Length of section: 7 ft - 1 in.

Thickness of insulation: 1.5 in.

Covering: Vapor barrier paper removed from original product. 16-mesh galvanized screen wrapper applied in the laboratory.

Pipe diameter: 4 in.

Method of Application

Method of fastening: 16 mesh galvanized wire fastened every 2 in. at the longitudinal joint with #22 copper wire

Position of joints: 1st section - Joints horizontal
2nd section - Joints vertical
3rd section - Joints horizontal

Other features: Wire mesh wrapper in one piece with 1 in. lapped seam.

Test Results

Amount fallen from pipe: None

Eccentricity: None

Separation at joints: Only slightly at butt joints after 120 hrs.

Cracks and ruptures: None after 48 hrs.

Fraying: None after 48 hrs.

Swelling: None

Erosion: None after 48 hrs. Slight erosion at buttjoints after 120 hrs.

Other damage: No damage that could be observed after 72 hrs. Except for the slight erosion at the joints and the usual embrittlement of the glass fibers, this specimen was in good condition after 120 hrs of boiling.

Moisture retention (percent): Not measured

Reference to photographs: Fig 10 is a view of the specimen after 120 hrs of boiling.

Figure 10

BOILING TEST OF PIPE INSULATION

Specimen 9

Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Preformed 1.5 in. Fiberglas (low temperature)

Binder used: Organic thermosetting resin

Length of section: 3 ft

Thickness of insulation: 1.5 in.

Covering: None

Pipe diameter: 4 in.

Method of Application

Method of fastening: 1st section - 4-3/4 in. straps
2nd section - 4-#12 copper wire
3rd section - 2-#12 copper wire

Position of joints: 1st section - Joints vertical
2nd section - Joints horizontal
3rd section - 45°

Test Results

Amount fallen from pipe: None as pieces

Eccentricity: Insulation layers flared out at seams

Separation at joints: Joints opened from 1/8 in. to more than 1 in.

Cracks and ruptures: No cracks or complete ruptures but surface cut by wires

Fraying: All joints showed fraying. Fraying more extensive on second section with joints located horizontally. See Fig 11

Swelling: Slight

Erosion: All seams showed erosion with delamination evident

Other damage: Wires cut into insulation. See Fig 12

Moisture retention (percent): Not measured

Reference to photographs: Fig 11 shows appearance after 72 hrs boiling
Fig 12 shows closeup of sections 2 and 3 fastened with wires. Mirrored view of second section shows nature of the fraying and delamination at the horizontal joint

Figure 11

BOILING TEST OF PIPE INSULATION

Specimen 10

Description of Material

Manufacturer: Pittsburgh Corning Glass Company

Identification name or symbol: Foam-Sil - A cellular silicate

Binder used: 99 + % pure silica

Length of section: 17 in.

Thickness of insulation: 1.5 in.

Covering: None

Pipe diameter: 4 in.

Method of Application

Method of fastening: With clamps screw thread tightened

Position of joints: 1st section - Joints horizontal
2nd section - Joints vertical
3rd section - 45°
4th section - Joints horizontal
5th section - Joints vertical

Covering used: None

Other features: All joints tight to slight crushing

Test Results

Amount fallen from pipe: None

Eccentricity: None

Separation at joints: Slightly at butt joints

Cracks and ruptures: About half of the individual pieces cracked circumferentially when steam was first turned on. No additional cracks developed during the test.

Fraying: None

Swelling: None

Erosion: Some of the cement used in fabrication of sections disappeared but not to point of unsealing joints after 144 hrs.

Other damage: Sections cracked on initial heating but cracks had not changed after 144 hrs. Cracks may have been caused by tight banding and pipe expansion on heating.

Moisture retention (percent): None

Reference to photographs: Fig 13 shows appearance of Foam-Sil after 72 hrs boiling

Figure 13

BOILING TEST OF PIPE INSULATION

Specimen 11

Description of Material

Manufacturer: Johns-Manville Company

Identification name or symbol: Thermobestos, Premolded Calcium silicate and asbestos fibers

Binder used: Calcium silicate

Length of sections: 36 in.

Thickness of insulation: 1.5 in.

Covering: None

Pipe diameter: 4 in.

Method of Application

Method of fastening: 1st section - Four 3/4 in. straps of aluminum
2nd section - Fiberglas mesh initially sewed at the longitudinal joint. Two metal straps added after 72 hrs because plastic mesh had stretched.

Position of joints: 1st section - Joints horizontal
2nd section - Joints vertical

Covering used: None except fiberglas mesh on second section

Other features: Aluminum straps replaced with steel straps after 24 hours

Section 11

Description of Material

Manufacturer: Cabot-Manville Company

Identification name or symbol: Thermokromex, Fireblock Section
Silicone and Asbestos Fibers

Engine model: Celtics Atlantis

Length of assembly: 32 in.

Thickness of insulation: 1.5 in.

Operation: Open

Pipe diameter: 6 in.

Method of Application

Making of Insulation: 1st section - Four 1/4 in. strips of silicone
2nd section - Fiberglas mesh initially wound
the longitudinal joint. Two metal straps
added after it has become plastic mesh has
solidified.

Fastening of Jackets: 1st section - Joints overlapped
2nd section - Joints overlapped

Covering Board: Does change flexibility based on pressure application

Other Features: Insulation always replaced with usual service after
24 hours

Test Results

Amount fallen from pipe: 1st section fell off in less than 24 hrs when aluminum straps sheared. 1st section replaced and steel straps used. 1st section off again after 48 hours boiling. Replaced and boiled for an additional 72 hours with one piece breaking off.

Cracks and ruptures: At 72 hours, seams of mesh-covered sections had opened about ¼ in. 2 straps were added to the second section and after 72 hours of additional boiling, the seam opening had not increased in the second section but had in the short unstrapped section.

Other damage: Some erosion at joints after 144 hours of boiling.

Moisture retention (percent): Not measured

Reference to photographs: Fig 14 shows condition of mesh-covered section after 144 hours of boiling.

Figure 14

BOILING TEST OF PIPE INSULATION

Specimen 12

Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Loose fill Fiberglas wool

Binder used: None

Length of section: 7 ft - 2 in.

Thickness of insulation: 1.5 in.

Covering: 1/4 in. mesh galvanized hardware cloth to retain loose fill insulation on pipe

Pipe diameter: 4 in.

Method of Application

Method of fastening: A weighed amount of loose fill Fiberglas was spread as evenly as possible on a flat piece of 1/4 in. mesh hardware cloth and held in place with big stitches of cotton string. See Fig 15 and 16. Even though the insulation was spread as evenly as possible, there was an appearance of clumps in the layer and probably variations in density. The width of the mesh wrapper and the amount of insulation used was such that the insulation would be compressed to a density of 7 lb/cu ft and a thickness of 1-1/2 in. when wrapped around the pipe with the wire mesh overlapping one inch at the edges. The wire mesh wrapper was held in place with 3/4 in. bands spaced 12 in. apart.

Test Results

Amount fallen from pipe: About 20 percent as weighed dry before and after boiling.

Other damage: Pipe exposed in many places as voids in an irregular pattern formed in the insulation.

Moisture retention (percent): None

Reference to photographs: Fig 15, left specimen, shows appearance after 72 hours boiling
Fig 16, bottom specimen, shows closeup of voids with a mirror image of the underneath portion.

Microscopic Examinations of Insulation: Samples of insulation were taken from the specimen at several locations after the test for microscopic examination. Microphotographs were taken of the glass fibers before and after boiling. Fig 16a shows the smooth, transparent, cylindrical appearance of the fibers when new. Fig 16b shows the appearance of the material near the surface of the envelope after boiling. It was broken into many short pieces, and appeared brown to the naked eye (perhaps the effect of the boiling water and steam on the oil treatment of the original material). Fig 16a and 16b are about 400 to 1 magnifications.

Figure 15

Figure 16

Figure 16a

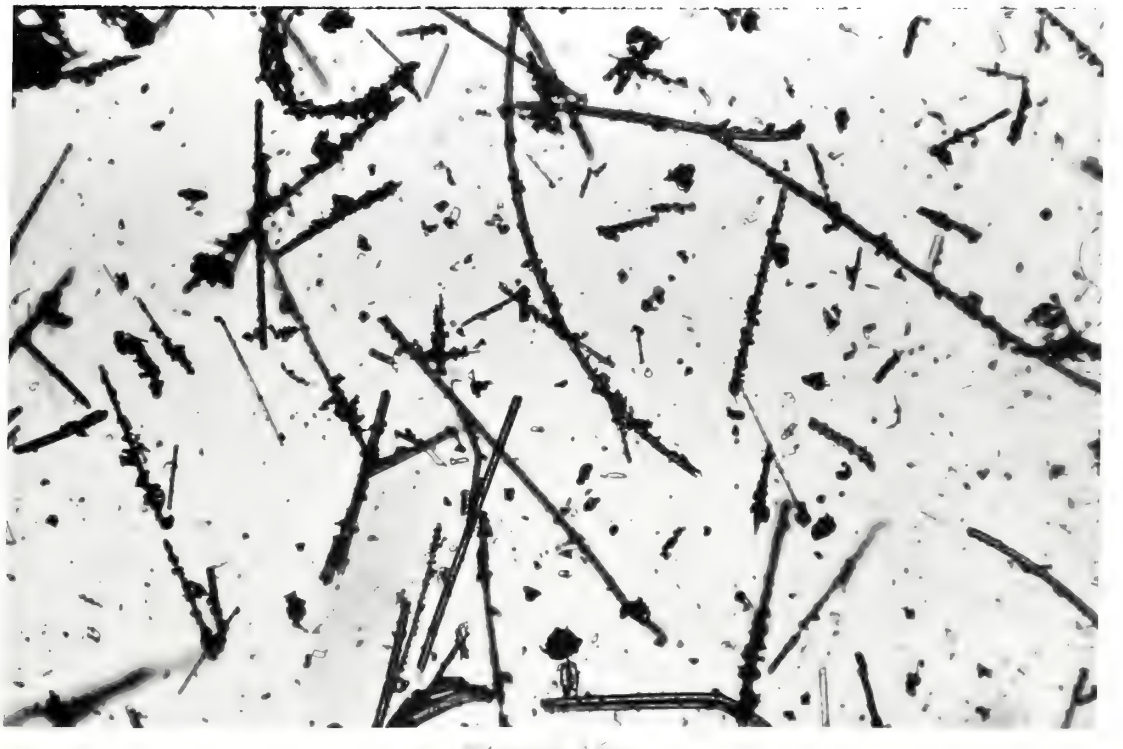

Figure 16c

BOILING TEST OF PIPE INSULATION

Specimen 13

Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Loose fill Fiberglas Wool

Binder used: None

Length of section: 7 ft - 2 in.

Thickness of insulation: 1.5 in.

Covering: 16-mesh galvanized screen wire used to retain loose fill insulation in the pipe.

Pipe diameter: 4 in.

Method of Application

Method of fastening: A weighed amount of loose fill Fiberglas was spread evenly on a flat piece of 16-mesh galvanized screen wire and held in place by stitches of cotton string. Even though the insulation was spread as evenly as possible, there was an appearance of clumps in the layer and probable variations in density. The width of the screen wrapper and the amount of insulation used was such that the insulation would be compressed to a density of 7 lb/cu ft and a thickness of 1-1/2 in. when wrapped around the pipe with the wire mesh overlapping two in. at the edges. The screen wrapper was held in place with 3/4 in. bands spaced 8 in. apart. See Fig 15.

Test Results

Amount fallen from pipe: About 10 percent of glass wool as weighed dry before and after boiling.

Other damage: Pipe exposed at several small spots and some local loss of fibrous material

Reference to photographs: Fig 15, right specimen, shows appearance after 72 hours boiling
Fig 16, top specimen, shows one spot where pipe exposed. 16-mesh screen wire provided a sort of flexible wrapping that tended to bulge slightly between straps

BOILING TEST OF PIPE INSULATION

Specimen 14

Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Kaylo

Binder used: Silicate

Length of section: 3 ft

Thickness of insulation: 1-1/2 in.

Covering: Canvas on 1st and short sections

Pipe diameter: 4 in.

Method of Application

Method of fastening: 3/4 pipe straps spaced 12 in. apart

Position of joints: 1st section - Joints horizontal
2nd section - Joints vertical
3rd section - Joints horizontal

Covering used: Canvas on 1st section and short section

Other features: Longitudinal joints did not close by 1/8 in. when insulation was tightly fitted to the 4 in. pipe. Insulation cavity was a little too small in diameter.

Test Results

Amount fallen from pipe: None after 72 hours

Eccentricity: None

Separation at joints: All joints opened up about 3/4 in. Insulation moved slightly on 4 in. pipe

Cracks and ruptures: None

Fraying: None

Erosion: Edges of vertical joints eroded so that circumference of two half sections lost about 1 in. after 144 hours boiling.

Reference to photographs: Fig 17 shows appearance after 72 hours boiling

Figure 17

BOILING TEST OF PIPE INSULATION

Specimen 15

Description of Material

Manufacturer: Owens-Corning Fiberglas Company

Identification name or symbol: Premolded Fiberglas, Standard

Binder used: Phenolic

Length of section: 3 ft.

Thickness of insulation: 1.5 in.

Covering: None

Pipe diameter: 4 in.

Method of Application

Method of fastening: 1st section, 4 straps - 72 hrs + 72 hrs.
2nd section, 4 copper wires - 72 hrs - new section, 4 straps 72 hrs.
3rd section, 2 straps - 72 hrs + 72 hrs

Position of joints: 1st section - Joints vertical
2nd section - Joints horizontal
3rd section - Joints vertical

Other features: None

Test Results

Amount fallen from pipe: After 72 hrs.
1st section, none.
2nd section, top half off pipe, part of bottom half hanging by wires. Replaced with a new length.
3rd section, none

Separation at joints: 1st and 3rd sections tight at longitudinal joints, 2nd section not on pipe so no butt joints.

Cracks and ruptures: None

Fraying: Very slight fraying at all joints.

Swelling: Very slight

Erosion: Butt joint end eroded to a concave shape on sections 1 and 3. Longitudinal joints eroded slightly at surface.

Other damage: After 144 hrs; 1st section; right side off pipe; part of left side hanging at bottom by straps.
After 72 hrs; replaced 2nd section; joints tight; joints show slight erosion at surface.
After 144 hrs; 3rd section; longitudinal joint tight.

Reference to photographs: Fig 18 shows the appearance of the insulation after 72 hours boiling. The first section, secured with straps, shows slight erosion and fraying. The second section, secured with wires, had separated from the pipe and a part had fallen into the bottom of the tank.

Figure 18

Specimen 16

BOILING TEST OF LOOSE FILL FIBERGLAS IN STILLWATER CLAY PRODUCTS CERT-A-BAR SYSTEM

Description of Test Specimen

Loose fill Fiberglas insulation, manufactured by Owens-Corning Fiberglas Company, was boiled inside a 14-ft test specimen of the Cert-a-Bar Clay Tile Conduit as manufactured by the Stillwater Clay Products Company. The insulation was packed to an average density of 5.5 lb/cu ft around a 4-inch pipe over a 2-inch pipe, both located inside a clay tile conduit made of 8-inch high side blocks and 8-inch semi-cylindrical arch tile.

The thickness of the insulation varied from a minimum of about 1.72 inches around the top half of the 4-inch pipe to a maximum of approximately 4.75 inches at some places underneath the 4-inch pipe.

The insulation had been subjected, during earlier tests, to several lengthy heating and cooling cycles, and to numerous wetting and drying cycles without boiling the insulation. The insulation had a semi-rigid molded characteristic before the boiling test and the fibers were brittle and broken into short pieces near the pipe.

Boiling Procedure

The ends of the system were sealed so it could be filled with water. The water level was indicated by an external sight glass and makeup water was added to replace that evaporated to maintain the water level at the top of the insulation space. Steam was introduced into the 4-inch pipe at a pressure of 125 psig and the pressure was maintained for 72 hours. The steam generated inside the conduit was vented to the atmosphere through two vertical 2 x 3-inch ducts placed, one at each end of the test specimen, at the top of the cylindrical arch tile forming the top of the conduit. The vertical leg of the two vents was about 4 feet long.

Insulation

The insulation had been evaluated, during earlier tests, by several laboratory heating and cooling cycles, and to measure radiation and drying cycles without insulating the laboratory. The insulation had a heat-rigid molded cementitious bolters the bolting bolt and the fibers were brittle and broken into sharp pieces near the pipe.

Boiler Procedure

The tanks of the system were marked so it would be filled with water. The water level was indicated by an external sight glass and tubing valve was added to replace that evaporated to maintain the water level at the top of the insulation system. There was fabricated like the 3-inch pipe as a pressure of its pump and the pressure was maintained for 72 hours. The steam generated inside the assembly was vented to the atmosphere through the vertical 2 3-inch ducts placed, one at each end of the test chamber, at the top of the cylindrical cork tile forming the top of the chamber, the vertical leg of the two vents was about 4 feet long.

Test Results

Fig 19 shows the appearance of the insulation in the conduit after boiling 72 hours. The dark streak at top center is a copper tube used at one time to introduce water to the insulation.

Fig 20 shows the appearance, at the downstream end, of the insulation. The 4 in. pipe is exposed for about 1/2 of its circumference on the lower side. There was considerable loss of insulation only near the outlet end for a distance of about 3 ft. A small amount was also lost at the inlet end. Apparently the insulation was carried out of the vertical vent pipes by the surging water and steam. Some pulverized glass fibers were found in the vent pipe at the end of the test. Except for the loss indicated above, there was little evidence of any voids in the remainder of the insulation.

Figure 19

Figure 20

U. S. DEPARTMENT OF COMMERCE
Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major laboratories in Boulder, Colo., is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside front cover.

WASHINGTON, D. C.

Electricity and Electronics. Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Engine Fuels. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.

• Office of Basic Instrumentation.

• Office of Weights and Measures.

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships. VHF Research.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering. Radio Meteorology.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Calibration Center. Microwave Physics. Microwave Circuit Standards.


NBS